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(71) Applicant: BORUNDI INTERNATIONAL PTY. LTD. [AU/AU]; Unit 7, 65-75 Captain Cook Drive, Caringbah, NSW 2229 (AU).			
(72) Inventors: VUKOVICH, Branko; 3 Kemble Place, Bilgola Plateau, NSW 2107 (US). VEAL, Colin, Preston; 24 Poppet Road, Wamboin, NSW 2620 (AU).			

(54) Title: MULTI LAYER VEHICLE TRACKING SYSTEM**(57) Abstract**

A vehicle tracking system is disclosed. The system uses management data generated or stored within a GSM digital mobile telephone to enable the location of the telephone to be determined by triangulation. The management data used includes Base Station Identity Code, Base Station Frequency, Signal Strength, Signal Quality and Timing Advance. The tracking system can also be used to track or locate shipping containers or to track or locate an individual carrying the mobile telephone.

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MULTI LAYER VEHICLE TRACKING SYSTEM

This invention relates to a method of tracking vehicles and other mobile bodies such as shipping containers, and even people, by using the management data generated within a mobile telephone operating on the GSM 5 digital mobile telephone system.

Several different techniques for tracking of motor vehicles have been implemented in the past. The major disadvantages of these methods are antenna shielding, high infrastructure costs and the need to provide a dedicated communications link from the vehicle to a monitoring station. For 10 example satellite based navigation systems are largely ineffective in high-rise building areas and inside buildings due to antenna shielding, while radio signal triangulation systems require dedicated and expensive infrastructure to be established to provide coverage of the required operating area. Both methods require the addition of a communications capability between the 15 vehicle and the monitoring station. The present invention overcomes these problems by using the very extensive and pre-existing mobile telephone infrastructure, which provides extremely good coverage and a high degree of redundancy so that it is possible to achieve reliable operation in areas where antenna shielding would make the satellite systems unreliable, and whilst not 20 having to fund the infrastructure associated with other radio triangulation systems. The mobile telephone system also provides the required communications link.

The present invention provides a multi-layer tracking system utilising the mobile telephone to provide an initial approximate location (Layer 1), a 25 more precise location by forcing the telephone to gather and report additional information (Layer 2) and, together with other commercial location devices that are controlled via the mobile telephone link, an exact location when required (Layer 3).

The present invention is essentially a radio signal triangulation system 30 the unique features of which are the extraction and use of data that is already generated within the GSM digital mobile telephone to provide the data required to perform the triangulation calculations.

Normal operation of the GSM digital mobile telephone system requires the mobile unit to determine and store a number of items of information relating to the local mobile telephone network. These data are used to make decisions relating to the management of calls to and from that mobile telephone. Some of these data that are of particular relevance to the present invention are:

- 10 Base Station Identity Code (BSIC)
- Base Station Frequency (ARFCN)
- Signal Strength
- Signal Quality
- Timing Advance (TA)

In normal operation, the mobile telephone will determine and store a full set of these data values in relation to the base station that is best positioned to immediately handle calls on behalf of that mobile. In addition it will determine and store some of these data values for up to six nearby base stations. The data is used internally within the telephone to manage calls to and from the mobile telephone to achieve the most efficient and reliable telephone operation. The present invention takes advantage of the existence of this data within the telephone as well as the ability to control the telephone so as to obtain a more complete set of data. The telephone may then be used to send the data to a remote monitoring station.

Each GSM base station transmits radio signals on one of 124 specific radio frequencies and therefore base stations may be co-located with other base stations or operated separately. When individually sited, the antenna system is usually (although not necessarily) designed to transmit and receive signals in an omni-directional pattern. When two or more base stations are co-located the antenna system is designed to have directional properties so that each base station services mobile telephones in a sector that is different from the other co-located base stations. Therefore, by determining the Base Station Identity Code it is possible to uniquely identify the operating base station and with knowledge of the antenna characteristics of that base station

to determine an approximate azimuth direction from the base station to the mobile telephone.

5 In one embodiment of the invention, the above listed management data related to each of the base stations may be used together with information related to the physical location and antenna characteristics of those base stations to determine the position of the mobile telephone by triangulation from the several base stations. The degree of redundancy of the information will provide a sufficiently accurate position definition for many applications.

10 A second embodiment of the invention provides enhanced accuracy by using the Timing Advance data. This data effectively provides the range from the mobile telephone to the base station. Addition of this information to the triangulation calculation further improves the accuracy of the position fix.

15 A third embodiment of the invention involves controlling the mobile telephone so as to transfer the call through one or more of the other base stations that are within range. In this way the Timing Advance data for each of the base stations is obtained. Adding this data to the triangulation calculations further enhances the accuracy of the position fix.

20 In order that the reader may gain a better understanding of the present invention, hereinafter are described one embodiment of the invention, by way of example only. A vehicle is fitted with a security system, a mobile telephone, an interface and control unit (ICU) and a commercial beacon transmitter. In the event of the vehicle being stolen or tampered with, the 25 security system will generate an alarm signal that will trigger the ICU. The ICU may then take control of the mobile telephone and initiate a telephone call to a monitoring station, passing over the link so established the available telephone management data, together with identification details of the vehicle. The ICU will also force the mobile telephone to operate via two or more base 30 stations in order to obtain additional Timing Advance data. At the monitoring station the call may initiate an alarm while at the same time the data received is correlated with known information about each base station in

order to perform the triangulation calculations and to present the location information on a map display. The monitoring station operator may then send back control information to the vehicle. This control information could, for example, cause the ICU to activate a commercial beacon transmitter in the 5 vehicle and may also immobilise the vehicle's engine. The monitoring station operator would then despatch an armed guard to the location indicated by the telephone data. The guard would identify the vehicle by means of a radio direction finding system tuned to the tracking transmitter.

The claims defining the invention are as follows:

1. A vehicle tracking system that uses management data generated within a GSM digital mobile telephone to provide data to enable determination of the position of the mobile telephone by triangulation.
- 5 2. The vehicle tracking system of claim 1 wherein the mobile telephone itself is used as the communications link to pass the acquired data to a monitoring station.
- 10 3. The vehicle tracking system of claims 1 and 2 wherein the mobile telephone is controlled in such a manner as to force it to operate via two or more base stations so as to generate additional management data in order to refine the triangulation calculations.
- 15 4. The vehicle tracking system of any one of claims 1 to 3 wherein the mobile telephone is used to convey control information from a monitoring station to the vehicle in order to control either the tracking system itself or other associated systems within the vehicle so as to enhance the ability of the monitoring station to locate the vehicle.
- 20 5. The vehicle tracking system of any of claims 1 to 4 applied in a manner so as to provide tracking/location of mobile telephones installed in shipping containers, railway rolling stock or carried on a person.

AMENDED CLAIMS

[received by the International Bureau on 6 March 1997 (06.03.97);
original claims 1-5 replaced by amended claims 1-5 (2 pages)]

1. A vehicle tracking system that uses management data stored within a
GSM digital mobile telephone to provide information to enable
determination of the position of the mobile telephone. In particular,
cell identity and Timing Advance (TA) information is accessed
directly from the mobile telephone. Cell identity information provides
the means of accessing a database containing the location and
characteristics of the cell's transmission antenna and thereby a
reference point and arc centred on that point, within which the mobile
telephone is located. Timing Advance information provides a good
estimate of the distance from the base station to the mobile telephone.
There is specifically no need for access to, or intervention by or
through, a mobile network base station or any other element of the
mobile cellular network equipment.
- 15 2. The vehicle tracking system of claim 1 wherein the mobile telephone
itself is used as both the source of the location data and the
communications link to pass the acquired data to a monitoring station.
- 20 3. The vehicle tracking system of claims 1 and 2 wherein the mobile
telephone is controlled in such a manner as to force it to operate via
two or more base stations so as to generate additional management
data in order to refine the location calculations. In particular, Timing
Advance information is generated for each additional base station so
used.
- 25 4. The vehicle tracking system of any one of claims 1 to 3 wherein the
mobile telephone is used to convey control information from a
monitoring station to the vehicle in order to control either the tracking
system itself or other associated systems within the vehicle so as to
enhance the ability of the monitoring station to locate the vehicle.

5. The vehicle tracking system of any of claims 1 to 4 applied in a manner so as to provide tracking/location of mobile telephones installed in shipping containers, railway rolling stock or carried on a person.

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00692

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl⁶: G01S 5/14, H04Q 7/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC : G08G 1/123, 1/127, 1/13; H04B 7, H04Q 7; G01S 3, 5, 13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT:

JAPIO:

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	US 5515419 A (SHEFFER) 7 May 1996 Whole document	1-5
P, X	WO 96/25830 A (EUROPOLITAN AB) 22 August 1996 Abstract	1-5
X	US 5218367 A (SHEFFER) 8 June 1993 Whole document	1-5

Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (06) 285 3929	Authorized officer S. AGGARWAL Telephone No.: (06) 283 2192

INTERNATIONAL SEARCH REPORTInternational Application No.
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C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5208756 A (SONG) 4 May 1993 Abstract	1-5
A	US 5389934 A (KASS) 14 February 1995 Whole document	1-5
A	US 5223844 A (MANSELL et al) 29 June 1993 Whole document	1-5

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No.
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This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
US	5515419	EP	643860	WO	9324911	US	5568535
		AU	30712/95	WO	9604155		
WO	9625830	AU	47373/96	SE	9500569	SE	9502976
US	5218367	EP	643860	WO	9324911	US	5515419
		US	5568535	WO	9604155	AU	30712/95
US	5208756	AU	13436/92	WO	9213284		